

- 70 -

CLAIMS

1. A vertical cavity surface emitting semiconductor laser, comprising:

5 a resonator that is arranged on a substrate and includes a first active region able to emit light in response to injection of an electrical current therein and a second active region able to emit light in response to external excitation light; and

10 a plurality of multilayer film reflecting mirrors which mirrors sandwich the resonator from two opposite sides, respectively;

wherein both the first active region and the second active region have gains at a wavelength the same
15 as a resonance mode of the resonator.

2. A vertical cavity surface emitting semiconductor laser, comprising:

20 a plurality of resonators that are arranged on a substrate and optically coupled with each other to form a resonance mode, one of the resonators having a first active region able to emit light in response to injection of an electrical current, each of the other resonators having a second active region able to emit light in response to external excitation light; and

a plurality of multilayer film reflecting mirrors which mirrors sandwich the resonators from two opposite sides, respectively;

wherein the first active region and the second 5 active regions have gains at a wavelength the same as the resonance mode.

3. The vertical cavity surface emitting semiconductor laser as claimed in claim 1 or claim 2, 10 wherein plural of the second active regions are provided.

4. The vertical cavity surface emitting semiconductor laser as claimed in any of claim 1 to claim 3, wherein each of the first active region and the second 15 active regions includes a mixed crystalline semiconductor of nitrogen and group-V elements.

5. The vertical cavity surface emitting semiconductor laser as claimed in any of claim 1 to claim 20 4, wherein

the first active region includes a multiple quantum well structure obtained by stacking plural quantum well layers and barrier layers, and each of the barrier layers is doped with p-

25 type impurities at a concentration in a range from 1 x

10^{18} cm $^{-3}$ to 1×10^{19} cm $^{-3}$.

6. A light emission device, comprising:
an external excitation light source; and
5 a vertical cavity surface emitting
semiconductor laser that includes a resonator that is
arranged on a substrate and includes a first active
region able to emit light in response to injection of an
electrical current therein and a second active region
10 able to emit light in response to external excitation
light, the first active region and the second active
region having gains at a wavelength the same as a
resonance mode of the resonator, and plural multilayer
film reflecting mirrors that sandwich the resonator from
15 two opposite sides, respectively;
wherein a wavelength of the external
excitation light source is less than or equal to a
wavelength corresponding to a bandgap of the second
active region.

20

7. A light emission device, comprising:
an external excitation light source; and
a vertical cavity surface emitting
semiconductor laser that includes a plurality of
25 resonators that are arranged on a substrate and optically

coupled with each other to form a resonance mode, one of the resonators having a first active region able to emit light in response to injection of an electrical current, each of the other resonators having a second active 5 region able to emit light in response to external excitation light; and a plurality of multilayer film reflecting mirrors which mirrors sandwich the resonators from two opposite sides, respectively;

wherein the first active region and the second 10 active regions have gains at a wavelength the same as the resonance mode.

8. The light emission device as claimed in claim 6 or claim 7, wherein the external excitation light 15 source is a semiconductor laser.

9. The light emission device as claimed in claim 8, wherein the external excitation light source is another vertical cavity surface emitting semiconductor 20 laser.

10. The light emission device as claimed in claim 8 or claim 9, wherein the external excitation light source and the vertical cavity surface emitting 25 semiconductor laser are integrated together.

11. An optical transmission system,
comprising:

a light emission device, which includes an
5 external excitation light source; and
a vertical cavity surface emitting
semiconductor laser, which includes a resonator that is
arranged on a substrate, which resonator includes a first
active region able to emit light in response to injection
10 of an electrical current therein and a second active
region able to emit light in response to external
excitation light, the first active region and the second
active region having gains at a wavelength the same as a
resonance mode of the resonator, and plural multilayer
15 film reflecting mirrors that sandwich the resonator from
two opposite sides, respectively;

wherein a wavelength of the external
excitation light source is less than or equal to a
wavelength corresponding to a bandgap of the second
20 active region.

12. An optical transmission system,
comprising:

a light emission device, which includes an
25 external excitation light source; and

- 75 -

a vertical cavity surface emitting semiconductor laser, which includes a plurality of resonators that are arranged on a substrate and optically coupled with each other to form a resonance mode, one of 5 the resonators having a first active region able to emit light in response to injection of an electrical current, each of the other resonators having a second active region able to emit light in response to external excitation light; and a plurality of multilayer film 10 reflecting mirrors which mirrors sandwich the resonators from two opposite sides, respectively;

wherein the first active region and the second active regions have gains at a wavelength the same as the resonance mode.